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COMPUTER ASSISTED TRANSLATION OF BRaille MUSIC
Phase II

PROFESSIONAL LIBRARY
AMERICAN PRINTING HOUSE FOR THE BLIND
LOUISVILLE, KENTUCKY

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INTRODUCTION

Beginning May 9, 1971, work was initiated at the American Printing House for the Blind (APH) on a project administered by the Library of Congress (LC), Division for the Blind and Physically Handicapped, to develop a program of Computer Assisted Translation of Braille Music.

Through May 9, 1972, the conclusion of the first year's work, many of these efforts were directed toward the design of a unique input device capable of encoding music data into computer-readable form. In addition, programs were written and some Braille music titles were produced, utilizing existing equipment.

Research was done in the area of music engraving, particularly concerning the use of automation, and a similar study was also made in the area of computers and music scholarship. In the academic community, varying approaches have been made toward the problem of music input.

The above efforts were documented in a year-end report submitted to LC in June, 1972. June 28, 1972 marked the beginning of a second period (Phase II) of work on this project.

The efforts of Phase II of this project are best described as a continuation of work initiated in the first year. Development of input hardware is complete and this equipment has been used to provide input for Braille.

We continue to study the particulars of Braille music--an endeavor of some magnitude. Accordingly, we attend meetings and workshops of various groups involved with Braille music notation and the education of blind musicians.

The following are descriptions of the progress achieved in Phase II of the project--June 28, 1972 through June 27, 1973. The events are not presented chronologically except as they are grouped under subject headings.

HARDWARE

During the week of September 21, 1972, a visit was made by our representative to Music Print Corporation (MPC), Boulder, Colorado, for what proved to be an interim inspection of the machine, an IBM 826 typewriter to card punch, being modified to a music input device. As a result of this, our first direct contact with the device, several minor but valuable changes in our original designs were effected while the unit was still in the completion stage.

During a final inspection, made during the week of October 23, 1972, finishing touches were made and a period of testing was afforded before shipment. We can now report that the machine was delivered on November 8, 1972, and has been used to prepare music for computer translation to Braille.

Thus modified, the unit is, in essence, a music typewriter interfaced with a standard card punch machine. As music is typed, codes corresponding to both the character set and their placement on the music staff are punched into computer-readable cards. Included is a control box, the functions of which are to rotate the platen to the desired positions of the staff and to send corresponding codes to the card punch. Further technical information on the device may be obtained by referring to our first year interim report number three, dated November 11, 1971-February 10, 1972.

SYSTEMS DEVELOPMENT

Input

Operational Procedures.

In printed music notation, there often exist a variety of accepted methods of indicating a particular music passage (a situation somewhat paralleling Braille music notation). While these slight variations cause no major problem in the performance of music, they are highly critical in terms of computer input, program writing, and actual data processing.

In approaching this problem, we favor allowing the operator to reproduce the printed page with as few deviations as possible, rather than dictating a very narrow set of input procedures. For example, if, in the print, the operator is likely to encounter two or three common methods of representing essentially identical information, we would prefer to be able to accommodate a practical variety of what can be determined as "standard" notations. From the standpoint of processing, this will require extremely flexible and highly intricate program writing.

However, as is often the case, methods of notation appear which are peculiar to a particular engraver, are difficult to anticipate, and thus require the establishment of certain conventions which then necessitate some deviation from the print. In addition, thought will continue to be given toward the development of efficient error correction procedures.

While several means of error correction are under development, the method we feel will be utilized most involves the use of standard typist's correction tape. The procedure will be to retype the error with the white tape (thereby rendering it the same color as the paper) after having generated a card-coded message to this effect via the auxiliary keypunch keyboard. Subsequently, the desired correct characters can then be typed over the now invisible corrections.

These input procedures, once established, will then become the basis for the writing of a comprehensive operator's instruction manual.

Editing.

Editing of the music text for the purpose of translation to Braille will likely fall into two categories. One will be the inclusion of control symbols to effect the decision-making aspects of Braille translation. We now know that there are some things which, even if programable, are probably best left under human control. There are others, of course, which definitely will require human intervention.

The second category will be the identification and modification of anomalies in the print, thereby relieving the operator of some of this responsibility.

Operator Requirements.

Determining the prior experience and musical knowledge requirements of operators and the amount of additional training needed will be decided in part by, as previously cited, how closely we will be able to follow the printed page and the types and amounts of prior editing supplied. It seems reasonable that the fewer decisions that are required of the operator, then the less training and experience will be required.

Maintenance.

Not being ignored is the reality that things mechanical, including our input device, need periodic servicing. Accordingly, an agreement was reached with IBM for the maintenance of the typewriter and keypunch sections of this equipment.

Programming

Maintenance.

Programs developed during the first year were used in further production. Some modifications were made to accommodate changes in the Braille mnemonics input symbols.

Guidelines for Development.

Several principles were adopted as a guide to program development for the second year. First, it seemed advisable that programs be designed so as to permit expansion in the processing of basic music signs and extension to added signs. It was also desirable that programs be readily modifiable to facilitate experimentation with different procedures. Another important principle was provision for intervention at points between input and final output to make corrections and editorial insertions. Finally, emphasis was placed upon arrangement of steps in logical succession more than upon execution time.

Some of the effects of following these guidelines were the analysis of processing into separate phases, the use of data areas of indefinite size, the incorporation of independent program subsections, and the assigning of meaningful names or abbreviations to data items intermediate between inkprint and Braille.

Error Correction.

The two-dimensional text written on the music typewriter and recorded by the attached keypunch creates some unusual conditions in regard to error correction. Making available to the operator procedures for correcting errors recognized while typing seemed essential to a workable system.

Programming was done to support several error correction procedures. The text, as corrected by the typist, is derived from input which may be a combination of original typing, error correction notation, and retyping.

Divisions of Music Data.

Considerable attention has been given to ways of partitioning music text into units for processing. It is helpful for computer handling if a body of data can be divided into units of manageable size and of a manageable number. Research to date does not indicate that music lends itself readily to this type of analysis.

An obvious music division, of course, is the measure. There are some music passages, however, such as cadenzas or unmeasured music, to which this division is not applicable. A more serious problem in using the measure as a basic processing division is the large amount and variety of data which one measure may include.

The metrical structure of music would seem to form a basis for partitioning. Beats and their fractional parts have a mathematical appeal. However, not all the data is included in this structure. Bar lines, word expressions, key changes and other features would need to be appended. The mathematics also becomes somewhat strained where irregular groups (triplets, septuplets, etc.) occur.

In some cases the principle of contiguity might serve to define a data item. An example is a flagged note consisting of note head, stem and flags. By virtue of spatial connection these parts make up a unit of data separate from other data. But, in other cases this principle is not definitive. For example, several successive notes with accidentals may be printed unspaced forming a contiguous item. Of course, in copying the notes on the typewriter, the operator probably would insert a separating space between a note and an accidental for the following note. It was felt, however, that it would be better to avoid making such spacing an absolute requirement.

Consideration has also been given to the factor of proximity. This factor might be the basis for identifying subareas of the two-dimensional data area. Musical association is often specified by symbols being placed close together. One example is the location of symbols of execution in relation to the notes to which they apply. Proximity, however, is not always a dependable means of determining association. For instance, in a closely harmonized chord, the connection between notes and their modifying accidentals or dots of duration may not correspond strictly to the distance between signs. Apparently, for a music reader, some important associations are made more on the basis of a wider knowledge of the selection than on the basis of mere physical distance.

Text Editing.

In the intermediate stage between inkprint and Braille, the music text is represented by a series of terms indicating the succession of music symbols. Included is information which is explicit or implicit in the original text, control information entered in the input by the operator, and auxiliary information required for brailleing. The development of this text requires access to a considerable span of data at one time and extensive alterations in the data.

To facilitate this aspect of processing, text editing routines were written. These routines make available a number of commands for text scanning and for making changes, insertions, and deletions in the text. The purpose is to permit the addition and removal of large amounts of text without losing text continuity.

Production Programs.

Programs were developed for each of five phases of processing between the music typewriter device and the Braille music code.

Input Device to Music Characters

The input device produces a typed copy of the music text and punched cards. Codes in the punched cards represent music typewriter graphics, rotation of the platen, and forward and backward spacing of the carriage. The first computer program essentially reconstructs the two-dimensional music text image from the data in the punched cards. It identifies each music character along with its vertical and horizontal coordinates.

This program is similar to the "826 to Array" program developed during the first year. However, the second year program has greater capacity for processing multiple characters in the same location (characters superimposed by the typewriter). Provision has also been made to handle error corrections included by the operator in the input.

Music Characters to Music Units

The program for the second phase attempts to interpret the meaning of the inkprint music graphics. Alphabetic items are separated from music signs. Basic forms and values are identified and modifiers are associated with items modified.

The output of the program consists of a representation in words of the music text. It is designed to be easily understood and provides a point at which changes may be made, if desired, before further processing.

Music Units to Edited Music Units

Information implied in the original music notation is stated more specifically in this phase. The pitch value of a note, for example, implied by its position on the staff and the nearest preceding clef sign, is inserted in the text. Other editorial additions specify details about features, such as octave numbers, which are particularly related to Braille representation.

Edited Music Units to Braille Sign Names

The fourth program converts the edited music text to a series of abbreviations which stand for the Braille music signs. The terms correspond to the meaning of the Braille characters. Currently, about 1250 sign names are used.

Another opportunity for intervention is available at this point, since changes may be made in the Braille sign names before going on to the last phase.

Braille Sign Names to Braille

The fifth program is designed to run simultaneously with the APH Grade 2 Braille translation program. Together the two programs process alphabetic and music data and set up the format of the Braille page. One of the functions of the music program is to effect the modifications required as the text is arranged into lines.

Auxiliary Programs.

Several programs have been written for peripheral operations. One of these is a program to display music input on the printer. Music typewriter graphics not available on the printer are represented by two-letter symbols. This two-dimensional display may be compared with the inkprint copy to determine whether or not a section of music text has been correctly entered into the computer.

PRODUCTION

While the emphasis during Phase II has been on development, production of Braille music has not been ignored.

Produced via Phase I methods was Book 2 of "40 Studies for Clarinet" by C. Rose, published by Carl Fischer. This serves as a companion to Book 1 (produced in Phase I) and completes the set.

40 Progressive Etudes for Trombone by Sigmund Hering (published by Carl Fischer) marks the first Braille music to be translated and embossed via the 826 system--the music typewriter-to-card punch device and its associated computer programs. Also in preparation with this system is "Selection of Concone Studies for Trumpet" by Donald S. Reinhardt, published by Elkan-Vogel.

An additional volume of a higher level of difficulty was produced utilizing a variation of the Braille mnemonics routines described in the Phase I final report. It is a keyboard volume, "The Joy of Each", published by Yorktown Press.

In producing music of this difficulty (Level 4 as defined in the Phase I final report) we have deliberately skipped Levels 2 and 3 because, from the standpoint of computer production, Level 4 is inclusive of the problems of polyphony, multiple staves, etc. contained in the intermediate levels. Furthermore, as there seems to be a lesser demand for music in Levels 2 and 3, we felt that the production of this keyboard volume would be a more significant contribution.

CONFERENCES

During the week of June 26, 1972, APH's music specialist was privileged to attend, on their invitation, the Association for Education of the Visually Handicapped 51st Biennial Conference, held at Miami Beach, Florida, and to address the music workshop concerning our computer project.

In addition to affording an opportunity to relate some insight into our efforts, this allowed us to meet and exchange ideas with these people so closely involved in the field of Braille music.

APH's representative also visited New York City during the week of August 28, 1972, to attend the meetings of the Music Advisory Committee of the Braille Authority, held at the Jewish Guild for the Blind. In an observer's capacity, it is felt that considerable insight was achieved into the problems of Braille music, and furthermore, cordial working relationships were established with the members of this committee.

Attended also were the Committee's May meetings, as well as the music workshops of the National Braille Association, all held in San Francisco during the week of May 7, 1973.

CONCLUSIONS AND RECOMMENDATIONS

Hardware

Having been afforded the opportunity for testing and utilization of the 826 music input device, it is our conclusion that, for the purpose of converting raw music data into machine-readable form, this approach is the most practical method available for this project.

Editing

We reaffirm our previous contention that our music project will always require the services of a music editor. Furthermore, we feel that regardless of which system is to be employed, music translation will require more editing than our literary program.

Programming

Developing and testing a series of music programs has emphasized the large amount of processing required to put inkprint music into Braille. The five programs to produce Braille from typed music require about 350,000 characters of computer storage. This may be compared to the program for translating library books and textbooks into Grade 2 Braille which requires a computer capacity of approximately 75,000 characters.

In designing the music programs, stress has been placed upon accommodation of additions and changes. At some future time, when a level of stabilization has been reached, modifiability will become less important and more emphasis can be given to program efficiency. When more is known about which aspects of music transcription can be handled by the computer and how broad a base of information is required for the various decisions, it will be possible to introduce more fixed patterns and precisely defined areas into program design and thus expedite execution on the computer.

The computer Braille music system itself may be expected to contribute to this optimization. A by-product of the system will be that samples of both inkprint music text and Braille music text will become available in machine-readable form. This text may be subjected to statistical analysis. Further information may be obtained by monitoring the operation of the computer while music is being processed. Thus, the system, as it is put to use, will help to place in perspective the task being performed.

It would seem that the effectiveness of computer production of Braille music will be related to achieving an appropriate structure for man-machine interaction. The complexity of the problem appears to require the involvement of certain human as well as computer decision-making resources. Particularly, in situations which present many options, human intelligence has applicability in its capacity for rapid elimination of those options which are improbable. Further exploration is needed in this area of interaction.

Output

The automatic stereograph machines developed at APH for our literary translation program have proven to be suitable as well for Braille music plates. The personnel who attend these machines are not required to know music and are provided with a computer-printed dot listing for reference.

Production

While efforts will be directed toward the reduction in the amount of editing required, routines developed thus far will be utilized for the production of additional titles. Further Braille will be produced experimentally and will include music of higher complexity such as more keyboard, scores, and vocal music.

Systems

1. 826.

It would now appear that the 826 system (including hardware, editing procedures, and associated computer programs), is a practical approach at least for the translation of music of moderate complexity. Computer factors such as the lengthy run time involved and the volume of internal storage required, render inconclusive the possibilities for the practical application of these programs to music of higher complexity.

2. Braille Mnemonics.

While the emphasis and preference remains on the development of the 826 system, the Braille mnemonics routines could eventually prove to be the most practical approach for computer assisted production of music of higher complexity. Should this prove to be the case, efforts toward some further refinements of these routines would then be initiated.

Braille Code

The Braille music code is complex indeed, considerably more so than the literary code. It can appear unclear at times whether the code is representing musical meaning or whether it is attempting to depict the equivalent of the inkprint notation. Based not upon extensive research on this matter (which, unfortunately, is beyond the scope of this project), it is our uneasy feeling that the code is occasionally at odds with itself on this issue.

Although some devices are available which attempt to indicate certain aspects of the exact inkprint disposition, current expert consensus indicates the inadvisability of their use in transcriptions for other than persons who specifically request them. It is our position that it would be appropriate, in terms of the future development of music notation for the blind, for some concerned organization to support an extensive project to investigate the Braille music code in depth.

